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13D.6 TRMM VALIDATION DURING THE TEXAS AND FLORIDA UNDERFLIGHTS EXPERIMENT (TEFLUN): EXPERIMENT DESIGN AND PRELIMINARY RESULTS

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1. INTRODUCTION

The TExas and FLorida UNderflights Experiment (TEFLUN) was a mission to obtain validation measurements for the Tropical Rain Measuring Mission (TRMM). TEFLUN is the first in a series of experiments using a combination of airborne and surface-based measurements to complement the satellite data. The DC-8 and ER-2 aircraft provide remotely sensed measurements, similar to those on the TRMM satellite. They are used for direct comparisons with TRMM where possible, but more frequently to simulate the TRMM data by flying over precipitation systems within experimental domain. Along with cloud physics data from an additional aircraft, surface-based measurements and computer models, the data sets collected will make unique contributions to our understanding of the low-latitude precipitation spectrum.

The overarching scientific objective of TEFLUN is to obtain a database suitable for case studies of a few MCSs, early in the TRMM lifetime, from which cloud-resolving models and forward radiative transfer models can be used to understand and improve the performance of the satellite and TRMM Ground Validation (GV) algorithms. The NASA ER-2 and DC-8 aircraft provide important remotely sensed measurements which provide similar, but higher resolution measurements than the TRMM radar and radiometer measurements. TEFLUN-A was focused on the TRMM Texas GV site, while TEFLUN-B was focused on the Florida TRMM GV site.

2. TEFLUN-A

TEFLUN-A (1 April to 15 May 1998) included the following facilities: a Lear Jet for microphysics measurements, the Texas A&M University Doppler Radar (ADRAD), the NOAA ETL wind profiler, an augmented surface network including additional raingages, disdrometers, supplemental soundings from mobile vans, and the Texas WSR-88Ds. The TEFLUN-A surface network map is shown in Fig. 1. The ER-2 was based at Eglin AFB in Florida, and the Lear Jet was based at College Station, TX. The ground network and forecasting effort was largely supported by Texas A&M University faculty and students. Most of the focus was on rain events within the dense raingage network near Houston (Fig. 1), or, within range of ADRAD. In the absence of suitable weather in Texas, TRMM was underflown within range of the other WSR88-D radars.

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The key instruments relevant to TRMM on the ER-2 included the ER-2 Doppler Radar (EDOP), the Advanced Microwave Precipitation Radiometer (AMPR), the Lightning Instrument Package (LIP), the Multi-channel Atmospheric Moisture Sounder (MAMS), and the Millimeter-wave Imaging Radiometer (MIR). The nominal flight altitude of the ER-2 is about 20 km.

The SPEC, Inc. Lear Jet provided a standard microphysics package, and also two new probes (Cloud Particle Imager (CPI) and High-Volume Particle Sampler (HVPS)). The CPI instrument provides unprecedented images of ice/water particles with dimensions between ~2 and 2000 μm. The HVPS instrument is geared toward larger particles (raindrops, snow aggregates, etc.) and will measure particles up to ~2 cm in size. The Lear flew at various altitudes in the rain and ice region (up to about 10 km altitude).

During TEFLUN-A, there were 7 science flights with the ER-2, and 8 Lear flights; there were 3 coordinated ER-2 flights. The ER-2 underflew the TRMM satellite during 5 flights. Various types of precipitation were overflown by the ER-2 and sampled by the microphysics aircraft. During one of the cases (April 18, 1998), the ER-2 was closely coordinated with the Lear, the Houston WSR-88D, and the enhanced surface measurements (NOAA profiler, NOAA X-band polarization radar, rain gages, etc.). There were three other interesting cases although not as well coordinated. Another very important outcome of the experiment was the climatological data collected by the surface network (gages, disdrometers, profiler, etc.).

3. TEFLUN-B

TEFLUN-B (1 August to 23 September 1998) was operated jointly with the overarching NASA Convection and Moisture Experiment-3 (CAMEX-3). CAMEX-3 was aimed at studying hurricanes with the ER-2 and DC-8 in a coordinated effort with NOAA (Hood et al.). The two NASA aircraft (ER-2 and DC-8) used the same instrumentation during these two field campaigns, although mainly the precipitation oriented instruments were of interest for TEFLUN-B. Additional facilities provided by TRMM specifically for TEFLUN-B include

included the University of North Dakota Citation-II aircraft for microphysics measurements, the NOAA ETL wind profiler, an augmented surface network including additional rain gages, disdrometers, the University of Iowa vertical pointing radar and video disdrometer, and supplemental mobile soundings. In addition, NCAR S-POL multiparameter radar investigators collaborated with NASA to provide extremely valuable information on rain, rain size distributions, and hyrdrometeor classification. The TEFLUN-B surface network map is shown in Fig. 2 Embedded within the raingage network shown in Fig. 2, is a smaller scale network called the "Master Site" that was located north of S-POL. The ER-2, DC-8, and UND Citation-II were based at Patrick AFB, Florida. The experiment coordination was performed from Patrick AFB, and the University of Central Florida (UCF) operated the surface network. Soundings were launched daily from UCF and from a mobile van (typically at the Master Site). Also, depending on the need, additional soundings were launched from Cape Canaveral Air Station.

The ER-2 payload was similar to that during TEFLUN-A. The DC-8 included the following key TRMM-related instruments: the Airborne Rain Mapping Radar (ARMAR), the Polarimetric Scanning Radiometer (PSR), the Lightning Instrument Package (LIP), the Airborne Multichannel Microwave Radiometer (AMMR), and the Cloud Aerosol Particle Characterization (CAPAC). The UND Citation-II had a standard microphysics package, plus the CPI and HVPS probes. Coordination of the DC-8 with a nominal cruise altitude of about 11 km, with the ER-2 and Citation-II, provided valuable TRMM validation information over rain systems. The Citation-II typically flew below the DC-8 between 3 and 10 km altitude. In numerous flights, the Citation-II flew both above and below the melting region. The three participating aircraft have very different capabilities but worked well together to measure a wide variety of convection and stratiform rain.

During the early part of the TEFLUN-B experiment, TRMM overpasses were opportune for coordinated daytime aircraft flights. There were 3 coordinated flights (ER-2, DC-8, and Citation-II) under TRMM and within the surface network and S-POL range; there were several other flights where one or two of the aircraft flew under TRMM. Also, several of the CAMEX-3 flights during hurricanes provided excellent TRMM validation. A few were well-coordinated with a TRMM overpass. In particular, Hurricanes Bonnie and Georges were sampled near the time of landfall. Continuous data was collected by the surface network (gages, disdrometers, and profiler).

4.0 SUMMARY

The TRMM TEFLUN validation experiment was focused on obtaining both TRMM and high-resolution TRMM-like aircraft measurements, within range of the Texas and Florida augmented surface networks. One of the key goals is to understand the relation of the vertical structure of precipitation (reflectivity profile, microphysics, etc.) with the satellite microwave brightness temperatures, radar reflectivities, and retrieved parameters using the TRMM satellite algorithms. A wealth of data has been collected on convective and stratiform rain in Texas and Florida. Efforts are underway to examine various aspects of the airborne remote sensing, microphysics, and surface-based rain measurements. Examples of data collected will be presented at the meeting.

ACKNOWLEDGEMENTS

This work was supported under the NASA Tropical Rain Measuring Mission by the NASA Headquarters program manager Dr. Ramesh Kakar. The TEFLUN-A and -B field campaigns had many dedicated participants. A partial list follows. Robbie Hood (MSFC) who was lead scientist of CAMEX-3, Mike Biggerstaff (Texas A&M) and Linwood Jones (UCF) who were responsible for the surface network in TEFLUN-A and TEFLUN-B, respectively. The microphysics measurements were handled by P. Lawson (SPEC), J. Stith (UND), J. Dye (NCAR),. and A. Heymsfield (NCAR). S-POL participation in TEFLUN-B was possible through the excellent cooperation of E. Brandes and Jim Wilson of NCAR. There were many other participants who contributed significantly to the experiment.

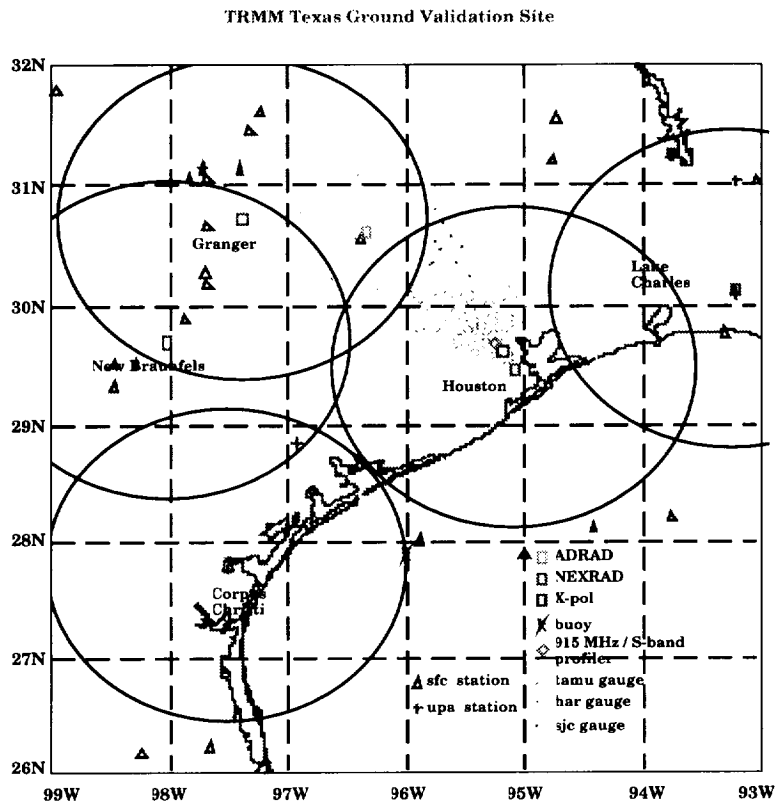

Figure 1. TEFLUN-A surface network.

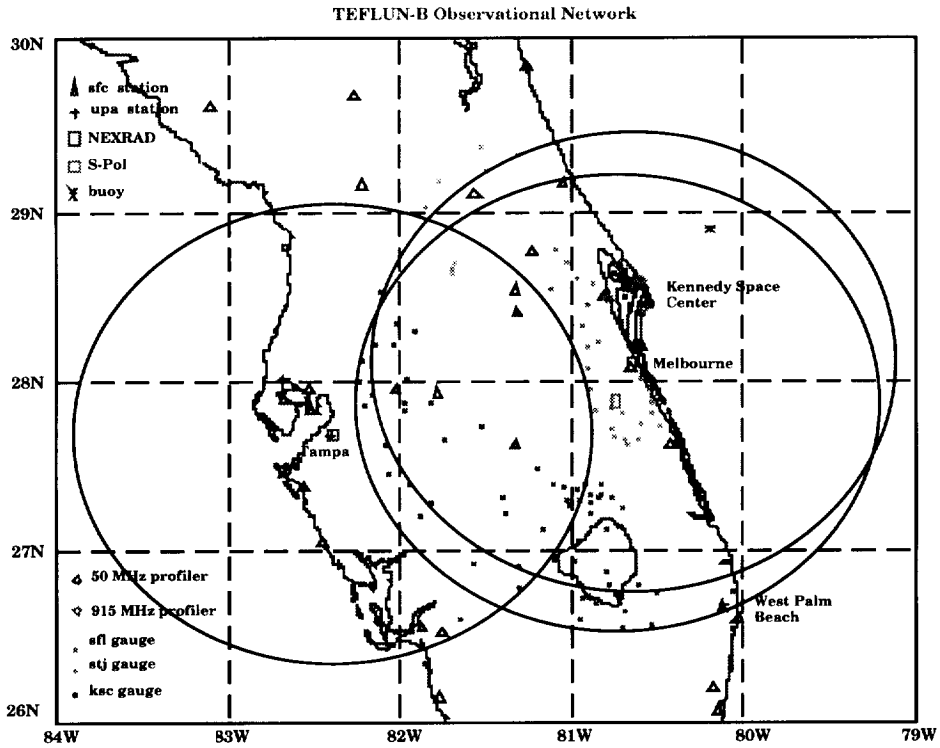

Figure 2. TEFLUN-B surface network.